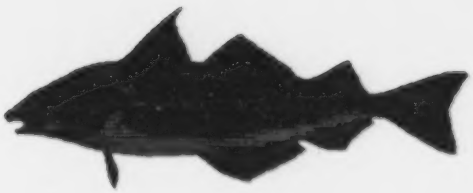
Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Maritimes Region
Canadian Science Advisory Secretariat
Science Advisory Report 2012/023

ASSESSMENT OF THE STATUS OF 4X5Y HADDOCK IN 2011



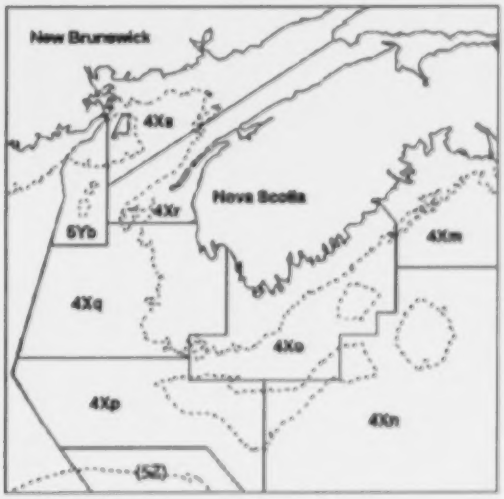


Figure 1. NAFO Units Area.

Context

Haddock (Melanogrammus aeglefinus) are found on both sides of the North Atlantic. In the west Atlantic, they occur from southwest Greenland to Cape Hatteras. A major stock exists in the southern Scotian Shelf and Bay of Fundy area. This bottom-dwelling species is a member of the cod family and feeds mainly on small invertebrates. It is most common at depths of 25-125 fathoms (46-228 m) and in bottom temperatures above 2 °C. Although seasonal migrations are evident within the stock area, there is relatively little exchange between adjacent Haddock stocks. Haddock in the Bay of Fundy grow more rapidly than those on the southern Scotian Shelf. Major spawning grounds are found on Browns Bank and peak spawning occurs in April/May. Historically, this fishery has been dominated by mobile gear except during 1990-93 when the proportion of landings taken by fixed gear was greater. Quotas for this stock were introduced in 1970 and a spawning season/area closure has been in place since that time.

The last assessment of 4X5Y Haddock took place in November of 2009 (DFO 2010). Fisheries Management in the Maritimes Region has requested that science advice be provided for the 2012/13 and 2013/2014 fishing years, including establishing precautionary approach reference points that are essential for the development of the Integrated Fisheries Management Plan.

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat regional advisory meeting of 19-20 January 2012 to review the assessment of 4X5Y Haddock. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Canada

SUMMARY

- Landings of 4X5Y Haddock in the fishing years ending 31 March 2010 and 2011 were 5,831 t and 5,370 t, respectively, relative to quotas of 7,000 t and 6,000 t. The quota in the 2011/12 fishing year remained at 6,000 t. A total of 2,518 t has been landed as of 19 January 2012, with a significant amount expected to be caught in the winter fishery.
- About 50 percent of the 4X5Y Haddock landings have come from Unit Area 4Xp in the last 4 years. This appears to be a fishery effect rather than a change in Haddock distribution.
- The summer research vessel survey biomass index in 2011 (47,874 t) was below the short (5 year: 50,470 t), medium (15 year: 51,434 t), and long-term (since 1970: 56,686 t) averages. However, it has been relatively stable over the past 8 years.
- The weight at age of 4X5Y Haddock remains low, as there have been declines in both condition and length at age for most ages since the early 1990s.
- Recent recruitment is variable, with poor year-classes in 2007 and 2008 and large year-classes in 2009 and 2010.
- Haddock remain distributed throughout the 4X5Y area, with 38 and 35% of the historical stock area encompassing 75% of the estimated spawning stock biomass in 2010 and 2011 respectively.
- Based on a Sequential Population Analysis model, spawning stock biomass (SSB, ages 4+) has remained relatively stable over the past two decades. While this model suggests an increase in SSB in the past few years, its strong retrospective pattern (tendency of the model to overestimate biomass) indicates that these values are likely overestimates.
- Using a Sissenwine-Shepard production model, Maximum Sustainable Yield (MSY) was estimated to be 14,700 t and Spawning Stock Biomass at MSY (SSB_{MSY}) was estimated to be 52,000 t. Biological reference points of 40% (20,800 t) and 80% (41,600 t) of SSB_{MSY} were suggested as the limit reference point (LRP) and upper stock reference (USR), but will be reviewed again at the next framework.
- Despite model uncertainties, 4X5Y Haddock spawning stock biomass is considered likely to be within the "cautious" zone, i.e., between the LRP and USR, and unlikely to be in the critical zone.
- Given the ongoing mortality of the strong 2006 year class, followed by two poor year classes (2007, 2008), and limited growth of 4+ fish, it is expected that SSB would decline in 2013 and 2014 without any fishing.
- The model was considered insufficient to provide meaningful projections for the next two years. However, for illustrative purposes, if a retrospective correction of 0.17 is applied (i.e., spawning stock biomass in the past three years is reduced by 17% in an effort to account for the retrospective), and catches of 5,500 t in 2012 (expected catch), 3,254 t in 2013 (F=0.25), and 3,226 t in 2014 (F=0.25) are assumed, SSB is projected to fall between the LRP and USR in 2012, 2013 and 2014.
- Given the continuing strong retrospective pattern in the model, and poor model fit to survey indices, a framework review for 4X5Y Haddock is recommended.

INTRODUCTION

This assessment uses a similar Sequential Population Analysis (SPA) model and data framework as Mohn et al. (2010). The catch is assumed to be known without error and the model is tuned to two surveys; the summer research vessel survey (RV survey) and a joint industry/DFO survey (ITQ survey). Given that Haddock grow faster in the Bay of Fundy than in the southern Scotian Shelf, the landings and catch at age are constructed separately for these

areas. Similarly, Haddock catches from the summer research vessel survey strata from the Bay of Fundy (482-495) and the Scotian Shelf (470-481) are handled separately.

Biology

Haddock (*Melanogrammus aeglefinus*) are found on both sides of the North Atlantic. In the west Atlantic, they occur from southwest Greenland to Cape Hatteras. A major stock exists in the southern Scotian Shelf and Bay of Fundy area. This bottom-dwelling species is a member of the cod family and feeds mainly on small invertebrates. It is most common at depths of 25-125 fathoms (46-228 m) and in bottom temperatures above 2°C. Although seasonal migrations are evident within the stock area, there is limited exchange between adjacent Haddock stocks. Haddock on the southern Scotian Shelf reach 16 inches (40 cm) and 1.3 pounds (0.6 kg) by age 4 on average. Growth slows thereafter, and Haddock reach only about 18 inches (46 cm) and 2.3 pounds (1.0 kg) by age 10. Haddock in the Bay of Fundy grow more rapidly than those on the southern Scotian Shelf. Approximately 50% of female Haddock are mature by age 3; however, the number of eggs produced by a female of this age is low and increases dramatically with age. Major spawning grounds are found on Browns Bank and peak spawning occurs in April/May.

ASSESSMENT

The Fishery

Haddock is harvested as part of a multi-species fishery. The total allowable catch (TAC) for Haddock was 7,000 t from 2006 to 2009, but was lowered to 6,000 t for the 2010 and 2011 fishing years (Figure 2, Table 1). However, catches have been lower than the TAC, averaging approximately 5,700 t since 2005.

Landings of 4X5Y Haddock in the fishing years ending 31 March 2010 and 2011 were 5,831 t and 5,370 t, respectively, relative to quotas of 7,000 t and 6,000 t. The quota in the 2011/12 fishing year remained at 6,000 t. A total of 2,518 t has been landed as of 19 January 2012, with a significant amount expected to be caught in the winter fishery.

There have been changes in the distribution of the fishery in the past decade, with a shift of effort from the Bay of Fundy to Unit Area 4Xp. About 50 percent of the 4X5Y Haddock landings have come from Unit Area 4Xp in the last 4 years. Of these, a substantial proportion is caught very close to the 4X/5Z boundary. This appears to be a fishery effect rather than a change in Haddock distribution.

Table 1. Landings (000s t) and TAC.

Year	1970-1979 Average	1980-1989 Average	2000-2004 Average	2005	2006	2007	2008	2009	2010	2011
TAC	14.7	21.4	8.9	8.0	7.0	7.0	7.0	7.0	6.0	6.0
TOTAL	18.6	19.6	7.5	5.1	4.7	6.8	5.7	5.8	5.4	

* Commencing in 2000, fishing year, landings and TAC refer to the period April 1st of the current year to March 31st of the following year.

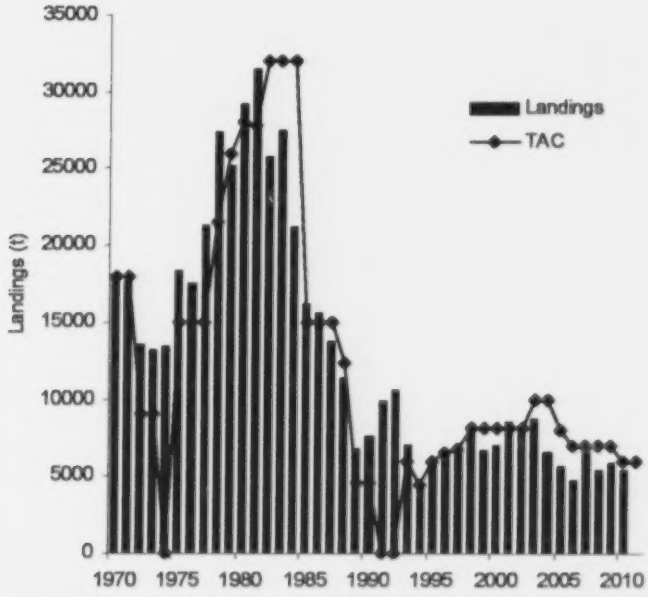


Figure 2. Long-term trends in 4X5Y Haddock landings and TAC.

Research Surveys

The stratified summer research vessel survey abundance and biomass indices are shown in Figures 3 and 4. The RV survey biomass index in 2011 (47,874 t) was below the short (5 year: 50,470 t), medium (15 year: 51,434 t), and long-term (since 1970: 56,686 t) averages. However, it has been relatively stable over the past 8 years.

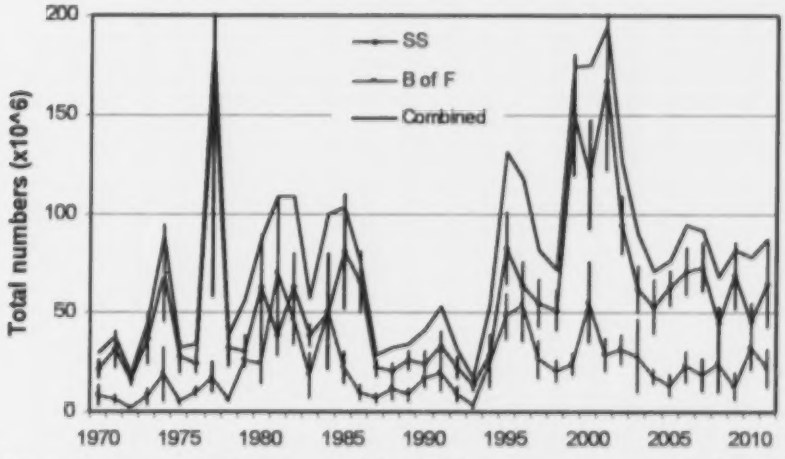


Figure 3. Summer RV survey stratified total numbers, by area, for 4X5Y Haddock.

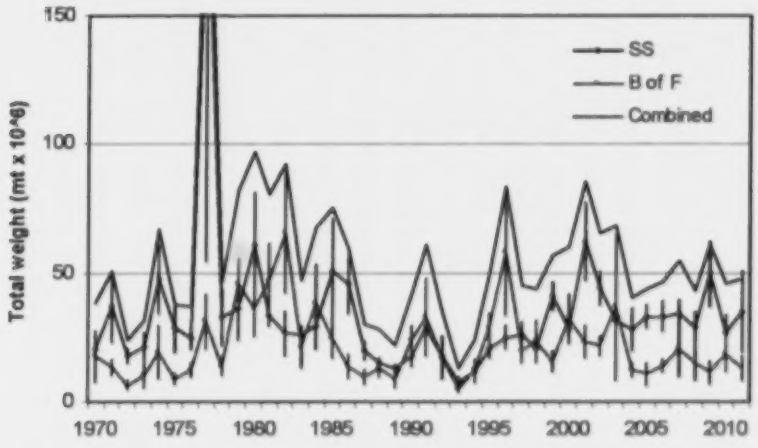


Figure 4. Summer RV survey total weight, by area, for 4X5Y Haddock.

The RV survey length frequencies for 2010 and 2011 are above the long-term average for lengths less than 12 cm (Figure 5).

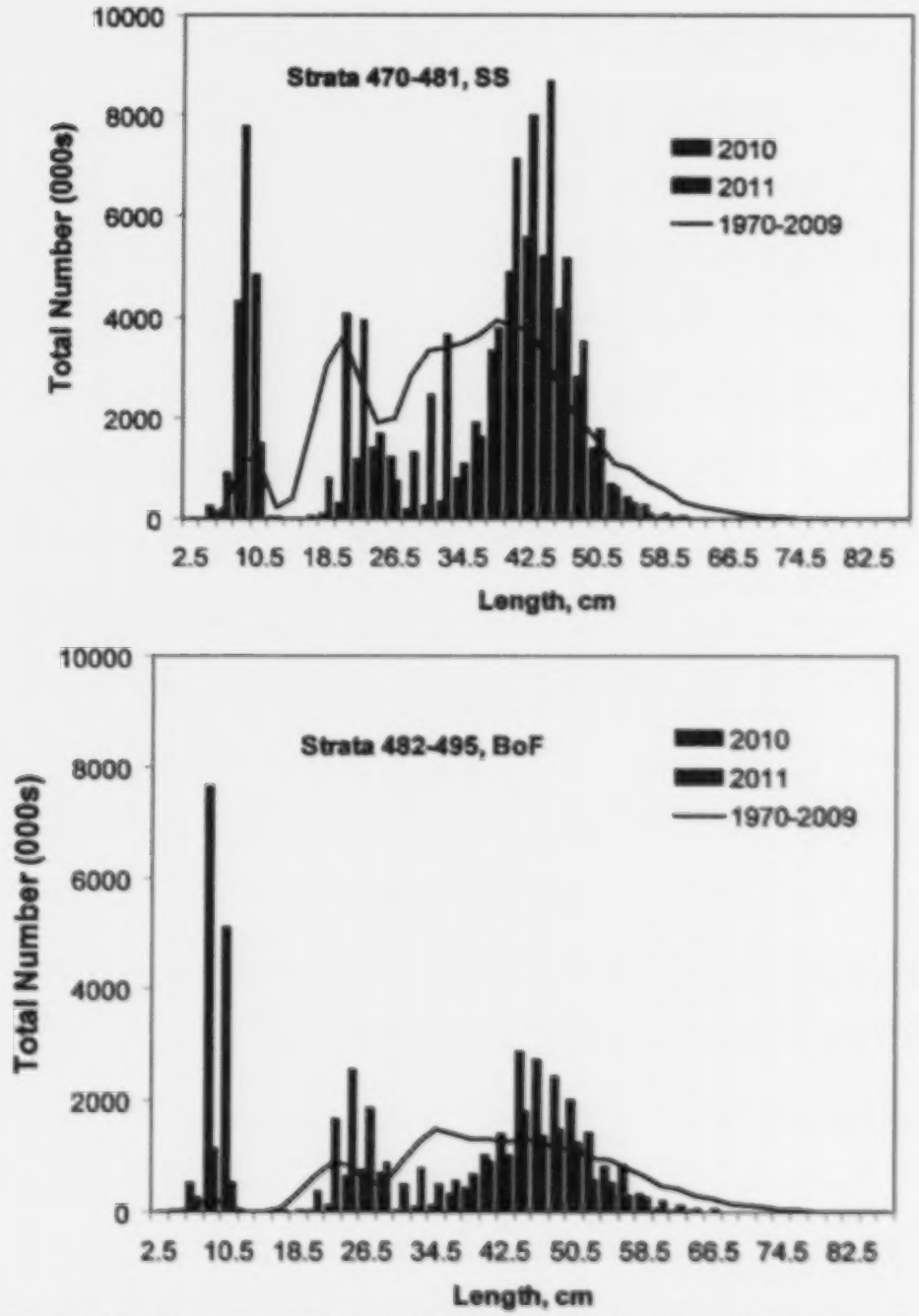


Figure 5. Length frequency plots for the Scotian Shelf (top) and Bay of Fundy (bottom).

The weight at age of 3 year old Haddock has declined slightly in both the Bay of Fundy and Scotian Shelf, but the decline in the weight at age of older fish (e.g., 5 and 7 year olds) has been more dramatic (Figure 6). Both length at age and condition of Haddock in the Bay Fundy and the Scotian Shelf components have declined since the early 1990s.

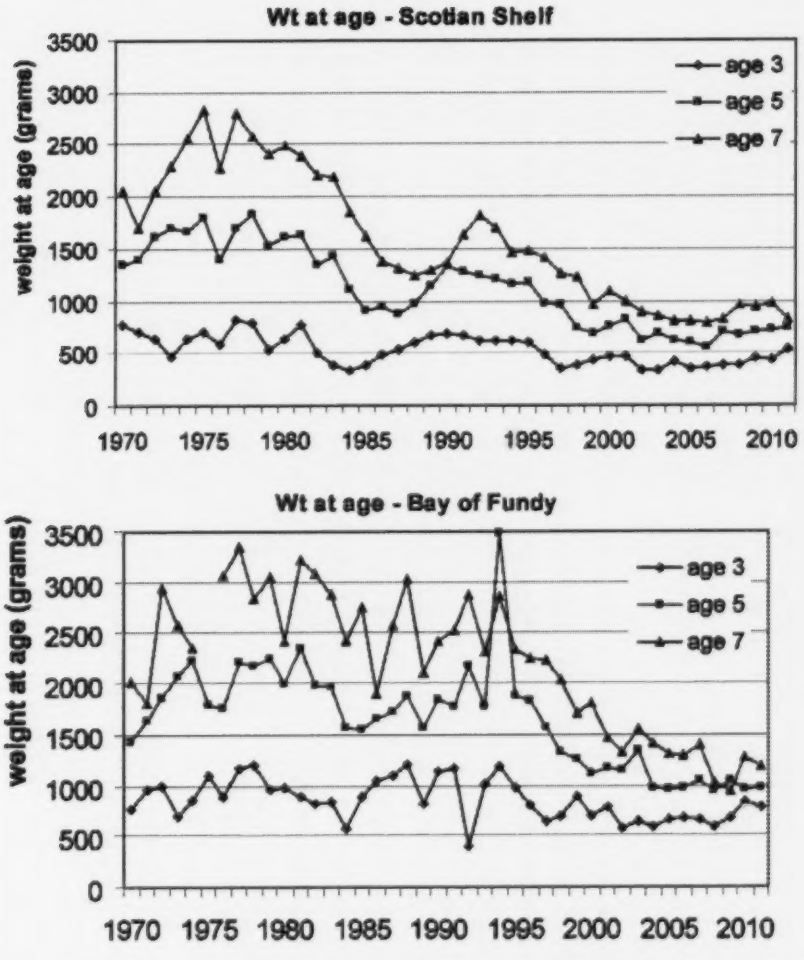


Figure 6. Summer RV survey mean weight-at-age, by area, for 4X5Y Haddock.

Recent recruitment is variable, with poor year-classes in 2007 and 2008 and large year-classes in 2009 and 2010. There also appears to be a greater number of older fish observed in the RV survey in recent years.

Haddock remain distributed throughout the 4X5Y area, with 38 and 35% of the historical stock area encompassing 75% of the estimated spawning stock biomass in 2010 and 2011, respectively.

The ITQ survey abundance and biomass indices have declined since 2001, but have been relatively stable in recent years (Figure 7).

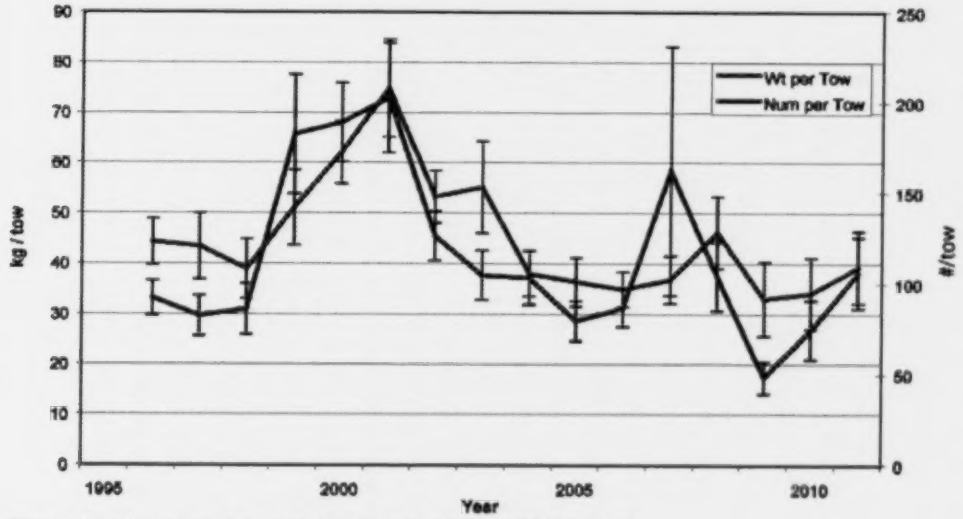


Figure 7. Abundance and biomass indices from ITQ survey.

The ITQ survey also indicates that the 2007 and 2008 year classes are weak, while the 2009 and 2010 year classes appear to be strong.

Model Results

The fit of the SPA model to the summer RV survey and the ITQ survey, and retrospective pattern are shown in Figures 8 and 9. The strong retrospective pattern seen in the Spawning Stock Biomass (SSB, ages 4+) reflects a mismatch between the survey and catch information, implying that recent estimates of biomass are overestimates.

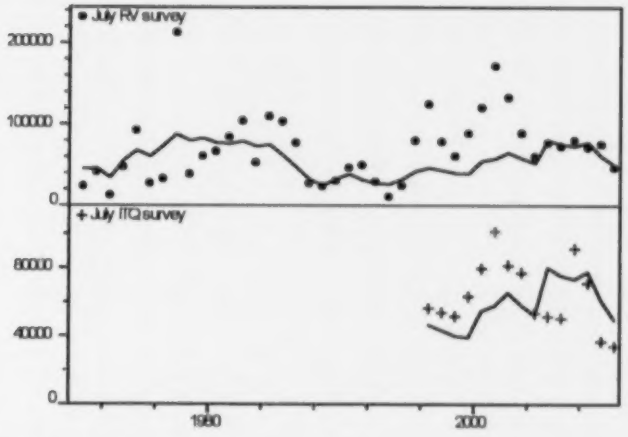


Figure 8. Population numbers x10^3 (ages 2-10) estimated from the model and the q-adjusted RV (upper) and ITQ (lower) surveys.

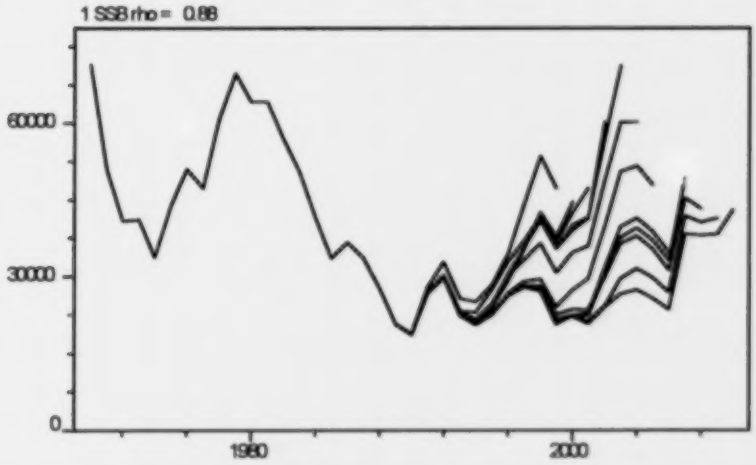


Figure 9. Retrospective pattern.

Based on the SPA model, spawning stock biomass has remained relatively stable over the past two decades (Figure 10). While this model suggests an increase in SSB in the past few years, its strong retrospective pattern (tendency of the model to overestimate biomass) indicates that these values are likely overestimates.

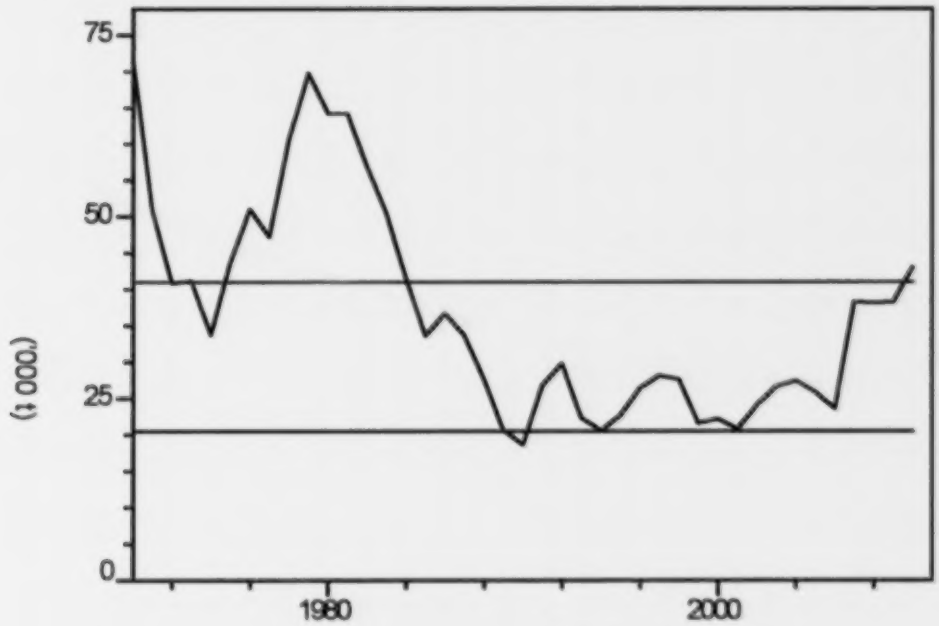


Figure 10. History of spawning stock biomass for 4X5Y Haddock with biological reference levels shown. The upper line is 0.8 of SSB_{MSY} and is the upper stock reference (USR). The lower line is the 0.4 SSB_{MSY} is the limit reference point (LRP).

Despite model uncertainties, 4X5Y Haddock spawning stock biomass is considered likely to be within the "cautious" zone, i.e., between the LRP and USR, and unlikely to be in the critical zone.

Biological Reference Points and Harvest Control Rules

Using a Sissenwine-Shepard production model, Maximum Sustainable Yield (MSY) was estimated to be 14,700 t and Spawning Stock Biomass at MSY (SSB_{MSY}) was estimated to be 52,000 t (Figure 11). Biological reference points of 40% (20,800 t) and 80% (41,600 t) of SSB_{MSY} were suggested as the limit reference point (LRP) and upper stock reference (USR), but will be reviewed again at the next framework. A target removal reference of 0.25 has been suggested but requires further review.

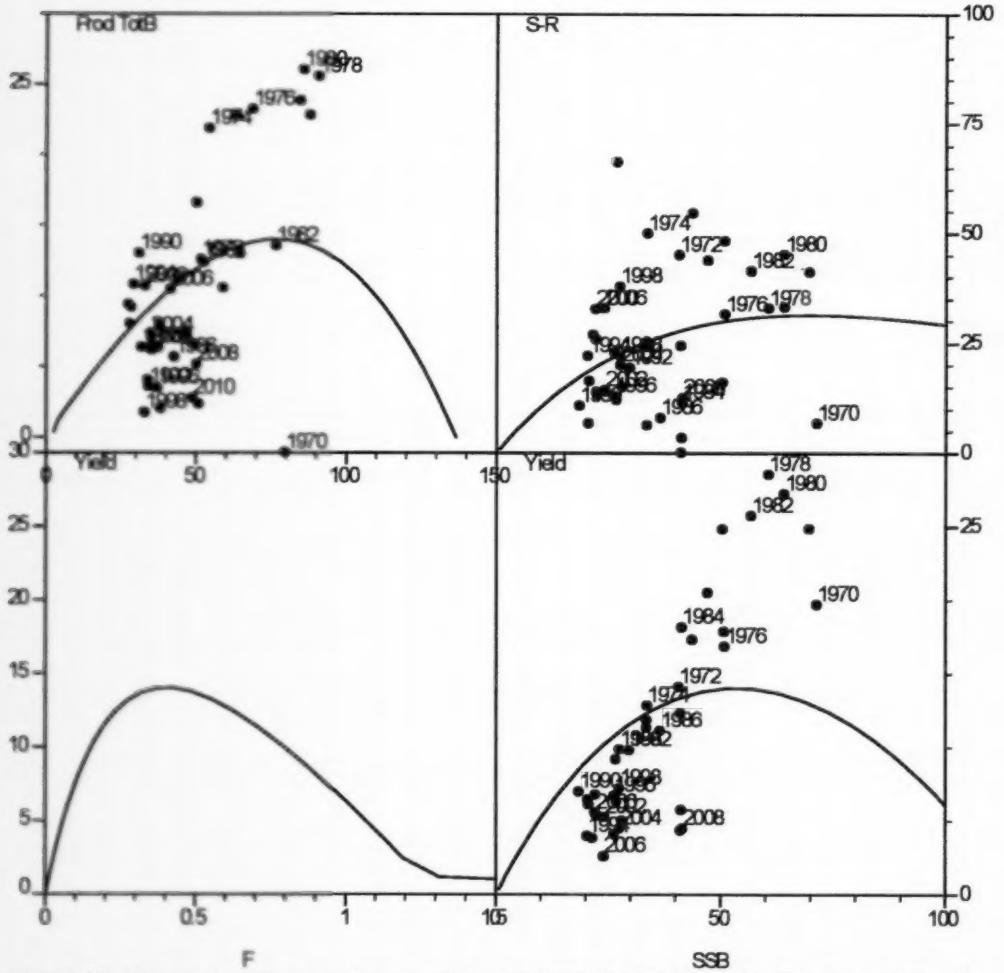


Figure 11. Sissenwine-Shepherd production model for 4X5Y Haddock. The upper left plot is production as a function of total biomass with the equilibrium line shown. The peak of this line at 14,700 t is MSY. The upper right plot is a stock-recruit relationship showing a Ricker curve. The lower left plot is yield (1,000 t) as a function of fishing mortality, and it shows F_{MSY} at about 0.43. And the lower right plot is yield as a function of spawning stock biomass.

Given the ongoing mortality of the strong 2006 year class, followed by two poor year classes (2007, 2008), and limited growth of 4+ fish, it is expected that SSB would decline in 2013 and 2014 without any fishing.

Projections

As mentioned previously, there is a continuing strong retrospective pattern in the model, and poor model fit to survey indices. As a result, the model was considered insufficient to provide meaningful projections for the next two years. However, for illustrative purposes, if a retrospective correction of 0.17 is applied (i.e., spawning stock biomass in the past three years is reduced by 17% in an effort to account for the retrospective), and catches of 5,500 t in 2012 (expected catch), 3,254 t in 2013 (F=0.25), and 3,226 t in 2014 (F=0.25) are assumed, SSB is projected to fall between the LRP and USR in 2012, 2013 and 2014. Figure 12 plots SSB versus fully recruited Fishing Mortality (F) since 1970, including the projected values for 2012, 2013, and 2014. If a larger retrospective correction is required, the risk that SSB would fall below the critical boundary would increase.

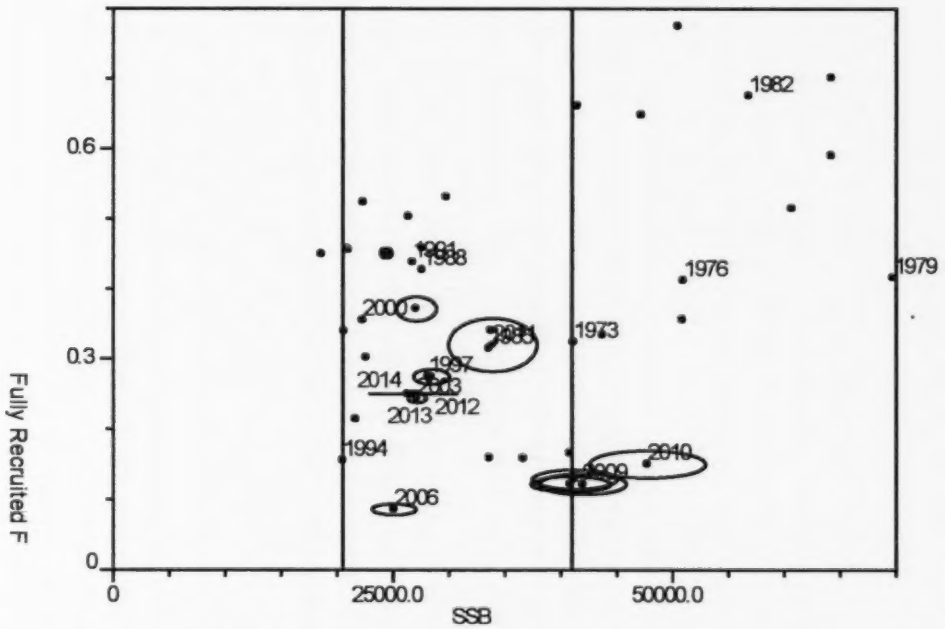


Figure 12. 4X5Y Haddock stock status in relation to reference points. The red dots are the projected values, while the ellipses are 1 standard deviation. Vertical lines are references at 40% (lower) and 80% (upper) SSB_{MSY}

Sources of Uncertainty

There are differences in growth between the Bay of Fundy and Scotian Shelf portions of this resource. Changes in fishing patterns may affect the development of the catch at age. Further, statistical areas and survey strata definitions of the respective areas are not identical.

It is possible that some element of the reported Unit Area 4Xp landings may be associated with the adjacent Georges Bank (5Z) stock.

As with previous assessments of this resource, the model residuals show some strong year effects, with positive residuals at all ages in some years and negative residuals at all ages in other years. The strong retrospective pattern seen in the SSB reflects a mismatch between the survey and catch information.

CONCLUSIONS AND ADVICE

The summer research vessel survey biomass index in 2011 (47,874 t) was below the short (5 year: 50,470 t), medium (15 year: 51,434 t), and long-term (since 1970: 56,686 t) averages. However, it has been relatively stable over the past 8 years.

The weight at age of 4X5Y Haddock remains low, as there have been declines in both condition and length at age for most ages since the early 1990s.

Recent recruitment is variable, with poor year-classes in 2007 and 2008 and relatively large year-classes in 2009 and 2010.

Based on a Sequential Population Analysis model, spawning stock biomass (SSB, ages 4+) has remained relatively stable over the past two decades. While this model suggests an increase in SSB in the past few years, its strong retrospective pattern (tendency of the model to overestimate biomass) indicates that these values are likely overestimates.

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Despite model uncertainties, 4X5Y Haddock spawning stock biomass is considered likely to be within the "cautious" zone, i.e., between the LRP and USR, and unlikely to be in the critical zone.

Given the ongoing mortality of the strong 2006 year class, followed by two low year classes (2007, 2008), and limited growth of 4+ fish, it is expected that SSB would decline in 2013 and 2014 without any fishing.

The model was considered insufficient to provide meaningful projections for the next two years. However, for illustrative purposes, if retrospective correction of 0.17 is applied (i.e., spawning stock biomass in the past three years is reduced by 17% in an effort to account for the retrospective), and catches of 5,500 t in 2012 (expected catch), 3,254 t in 2013 (F=0.25), and 3,226 t in 2014 (F=0.25) are assumed, SSB is projected to fall between the LRP and USR in 2012, 2013 and 2014.

Given the continuing strong retrospective pattern in the model, and poor model fit to survey indices, a framework review for 4X5Y Haddock is recommended.

SOURCES OF INFORMATION

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DFO. 2010. Assessment of the Status of Division 4X5Y Haddock in 2009. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/005.

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